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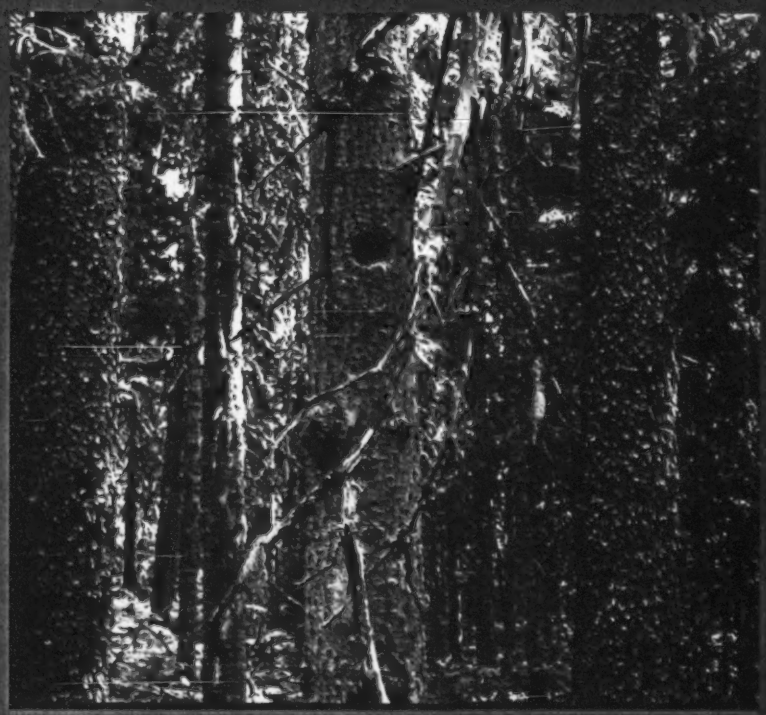
Ecosystem and Tree Attributes Affecting the Presence of Functional Wildlife Tree Types



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051

Ecosystem and Tree Attributes Affecting the Presence of Functional Wildlife Tree Types

B.H. Heemskerk, B.J. Rogers, and S.C. DeLong

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ABSTRACT

Wildlife Trees play a significant role in maintaining species richness in forested ecosystems by providing critical habitat. This study was completed to develop a better understanding of the relationship between ecosystem and tree attributes and an established functional Wildlife Tree type classification. Data from four studies conducted in different ecosystems in central British Columbia are compared in this paper. The four study areas were: (1) boreal aspen forests, (2) mixed conifer forests in the boreal foothills, (3) mixed conifer forests in the moist interior plateau, and (4) mixed conifer forests in the interior wet belt.

In each study area, tree species were evaluated by diameter classes for the percentage of live versus dead stems and functional Wildlife Tree types based on an existing classification system, and results within and among study areas were then compared. The combined tree sample size totalled almost 19 300 stems, comprising 10 different tree species. To provide a link to provincial Wildlife Tree policy, each tree's value was ranked using guidelines established by the provincial Wildlife Tree Committee.

We found that both the number of trees displaying at least one functional Wildlife Tree type and the number of functional types per tree showed a positive trend with increasing diameter of dead stems. This trend varied amongst tree species. Our study results show that black cottonwood (*Populus balsamifera* L. ssp. *trichocarpa*), trembling aspen (*Populus tremuloides* Michx.), western redcedar (*Thuja plicata* Donn ex D. Don), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) provide the greatest diversity of functional Wildlife Tree types.

Findings from the four study areas suggest that large-diameter trees of certain species must be maintained within forests in order to avoid the loss of distinct structural attributes, represented by functional Wildlife Tree types, which provide important habitat for many wildlife species. This information provides a basis for understanding the variability and similarities among different ecosystems of unique structural characteristics of Wildlife Trees, thereby providing resource managers with ecosystem-specific information and helping to avoid generalized prescriptions that may not reflect the managed sites in question.

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A Wildlife Tree (WT) is defined as any standing, live or dead tree with special characteristics that can provide valuable habitat for wildlife (Figure 1). Special characteristics of a WT serve as critical habitat for denning, shelter, roosting, and foraging (FPC 1995) and can be categorized by 10 different functional WT types as defined by Keisker (2000). WTs play a significant role in maintaining biodiversity in forested ecosystems. Bunnell et al. (1999) suggested that in the majority of forest types about one quarter to a third of vertebrate fauna use WTs for reproduction or roosting.

Based on current understanding, at least 66 and perhaps as many as 90 (12–16%) wildlife species in British Columbia are reliant on WTs to meet critical habitat requirements throughout their life histories (Steeger et al. 1993; B.C. Ministry of Forests 2000; Fenger et al. 2006). Keisker (2000) also identifies 79 wildlife species located in north-central British Columbia that are reliant on WTs. Of the 136 species and subspecies of breeding birds and mammals in British Columbia that are Red- or Blue-listed, 23 (17%) are WT-dependent (Fenger et al. 2006). Red- and Blue-listed species include species that have been legally designated as threatened or endangered under the *Wildlife Act*, have been extirpated, or are particularly sensitive to human activities or natural events (BC CDC 2003). Ten of these species (Appendix 1) are "identified wildlife or species at risk" in the Identified Wildlife Management Strategy (IWMS) of the *British Columbia Forest and Range Practices Act* requiring "special management attention" (IWMS 2004). In addition, the IWMS lists six other species (Appendix 1) whose habitat is enhanced when WTs are retained. This information clearly shows the need to better understand the occurrence of specific characteristics that make a WT valuable, to facilitate better management for WTs in our forested ecosystems.

Keisker (2000) presents a classification for 10 functional WT types potentially utilized by terrestrial vertebrates; she provides a time- and cost-effective means of ascribing value to a tree without extensively surveying each tree for use by individual wildlife species (Table 1). Each of the 10 functional types is based on a critical feature or features, and the types are not mutually exclusive. Thus, it is possible for one particular tree to be classified as having multiple functional WT types. The 10 types fall into two main categories: reproduction/resting and foraging. The reproduction and resting category includes substrates for excavation of cavities (types 1 and 2), existing cavities (types 3 and 6), and large supporting structures (types 7 and 8). The foraging category is broken down into feeding substrates (type 9) and hunting perches (type 10).

In British Columbia and throughout the world, forests are actively managed, potentially altering tree species composition and size, and the amount of dead standing and fallen trees (Bunnell et al. 1999; Nilsson et al. 2001; DeLong et al. 2004). Forest management can also differentially affect certain types of WTs, ultimately altering the species richness of particular terrestrial vertebrates and invertebrates (Steeger et al. 1993; Lofroth 1998; Bunnell et al. 1999; Fridman 2000; Johnson and Freedman 2002). For example, a study by Fan et al. (2004), which used models to compare the abundance of WTs with cavities, suggested that some harvesting techniques reduced their abundance by 28–34%, while another reduced it by only 9–11%. DeLong et al. (2004) found that, by altering harvesting spatial patterns, snag loss could be reduced

FIGURE 1 *Examples of Wildlife Trees. (upper and lower right photos courtesy of Aleza Lake Research Forest)*

TABLE 1 *Wildlife Tree types (WT types), arranged by function, as defined by Keisker (2000)*

Main functions of Wildlife Trees	Configurations of Wildlife Tree features required by wildlife species occurring in the SBS, ESSF, and ICH zones		Main users
Reproduction/Resting: a. Substrates for excavation of cavities	WT1:	Hard outer wood surrounding decay-softened inner wood	Woodpeckers (stronger excavators)
	WT2:	Outer and inner wood softened by decay	Woodpeckers (weaker excavators), chickadees, Red-breasted Nuthatch
Reproduction/Resting: b. Existing cavities	WT3:	Small, excavated, or natural cavities	Chickadees, nuthatches, Northern Pygmy-Owl, swallows, other passerines, bats
	WT4:	Large, excavated, or natural cavities	Ducks, American Kestrel, owls, Mountain Bluebird, European Starling, Northern Flicker, swallows, other passerines, bats, squirrels, marten
	WT5:	Very large natural cavities and hollow trees	Vaux's Swift, mustelids, Barred Owl, bats, red squirrel
	WT6:	Cracks, loose bark, or deeply furrowed bark	Brown Creeper, bats
Reproduction/Resting: c. Large open-nest supports and other non-cavity sites	WT7:	Witches' broom	Squirrels, mustelids, Merlin, owls
	WT8:	Large branches, multiple leaders, or large-diameter broken tops	Great Blue Heron, diurnal raptors, owls, Common Raven
Foraging: a. Feeding substrates	WT9:	Arthropods in wood or under bark	Woodpeckers
Foraging: b. Hunting perches	WT10:	Open-structured trees in or adjacent to open areas	Diurnal raptors, owls, various passerines, Belted Kingfisher

by up to 70%. Changes in species richness are prevalent in European forests that have been under active management for multiple harvesting rotations. Managed multi-rotation European forests have in many cases become deficient in snag abundance. It has been suggested that the systematic removal of old trees and deadwood from European forests has significantly contributed to the 20–40% of forest-dwelling species that are threatened or in danger of extinction (Bretz Guby and Dobbertin 1996; Fridman 2000; Fridman and Walheim 2000; Lonsdale et al. 2008).

Here in North America, we are in the early stages of realizing the implications of our management practices in the resulting "second-growth forests." In order to avoid the same results as in multi-rotation European forests, managers are altering their strategies to maintain appropriate habitat. In some cases, forest managers are trying to artificially reproduce trees with "critical features." Lewis (1998) summarizes the artificial re-creation of WTs in the Pacific Northwest with costs ranging from $20 to $50 per tree using techniques that included explosives, girdling, and modification using a chainsaw. Managers may be able to avoid this loss of forest habitat and subsequent costs incurred to re-create it by increasing our knowledge of the habitat value of specific WTs and how our management actions affect these trees.

Numerous studies have illustrated the strong correlation between tree size and state (live or dead), and a tree's potential to provide ecological values (Samuelsson et al. 1994; Bull et al. 1997; Stevens 1997; Lofroth 1998; Bunnell et al. 2002; DeLong et al. 2005, 2008). Having a shortage of large trees associated with a wide range of habitat attributes in managed stands of the future has become a management concern (Stevenson et al. 2006). Ecosystem-specific baseline data on occurrence and abundance of WT types are needed for managers to make informed decisions. Forest managers are also now utilizing simulation modelling to examine the implications of management strategies. The purpose of this meta-analysis is to provide information about the relationships between the functional WT type classification of Keisker (2000), and tree species, tree condition (live or dead), and tree diameter in our four ecosystems studied. These relationships then can be used (1) to help forest practioners make informed management decisions regarding WT management, and (2) to provide information for future simulation modelling to help predict the implications of alternative management practices on the supply of functionally important trees.

2 METHODS

2.1 Study descriptions

We compared data from four independent studies completed to investigate old-growth stand dynamics and attributes in distinctly different ecosystems in north-central British Columbia. As a part of each study, data were gathered on: (1) tree species, tree status (live or dead), and tree diameter-at-breast-height (dbh) according to the Ministry of Forests *Cruising Manual* (B.C. Ministry of Forests 2002); (2) functional WT habitat types according to Keisker (2000); (3) detailed site description according to the *Field Manual for Describing Terrestrial Ecosystems* (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1998); and (4) classification using the Biogeoclimatic Ecosystem Classification (BEC) system (Meidinger and Pojar 1991).

The combined number of trees sampled across all four studies totalled 19 294 (Table 2). White spruce (*Picea glauca* (Moench) Voss), and hybrid white spruce (*Picea glauca* x *engelmannii* (Moench) Voss var. (Parry ex Engelm.) Boivin) were grouped together for comparison, while black spruce (*Picea mariana* (P. Mill.) B.S.P.) was examined individually. A brief description of each study area is included below, including any differences in methodology between studies.

2.1.1 Aspen study Boreal aspen forest ecosystems were surveyed by collecting data from 69 plots in 23 forest-cover polygons in the northeastern section of the Northern Interior Forest Region. The 23 polygons were located on zonal sites in the Peace variant of the moist warm Boreal White and Black Spruce (BWBSmw1) subzone (DeLong et al. 1990).

In each forest polygon, three 100-m transects were established at random azimuths. At the midpoint of each transect, a 0.1-ha circular plot was established where information for all trees >7.5 cm dbh was recorded. At one of three plots established in each polygon, a detailed site description was completed (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1998).

TABLE 2 *Summary of sample size by tree species from the Aspen, Boreal, SBS, and ICH studies*

Tree species	Aspen OG Study			Boreal OG Study			SBS OG Study			ICH OG Study			Grand total
	Dead stems	Live stems	Total	Dead stems	Live stems	Total	Dead stems	Live stems	Total	Dead stems	Live stems	Total	
Act (black cottonwood)	506	1410	1916	0	2	2	1	7	8	6	20	26	1952
At (trembling aspen)	533	3122	3655	31	47	78	24	102	126	23	56	79	3938
Ep (paper birch)	11	38	49	0	0	0	1	9	10	4	18	22	81
Bl (subalpine fir)	0	7	7	414	1603	2017	19	74	93	120	143	263	2380
Cw (western redcedar)	0	0	0	0	0	0	0	0	0	122	807	929	929
Fd (Douglas-fir)	0	0	0	0	0	0	0	7	7	20	300	320	327
Hw (western hemlock)	0	0	0	0	0	0	0	0	0	102	835	937	937
Pl (lodgepole pine)	31	183	214	331	1303	1634	474	2405	2879	6	63	69	4796
Sb (black spruce)	2	49	51	81	263	344	64	333	397	0	0	0	792
Sx (spruce)	15	200	215	204	1518	1722	102	869	971	46	208	254	3162
Total	1098	5009	6107	1061	4736	5797	685	3806	4491	449	2450	2899	19294

Of 6107 trees sampled in this study (Table 2), species included black cottonwood, trembling aspen, paper birch (*Betula papyrifera* Marsh.), subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.), lodgepole pine (*Pinus contorta* var. *latifolia* Dougl. ex Loud.), black spruce, and white spruce.

2.1.2 Boreal study Mixed conifer forests in the boreal foothills were surveyed by collecting data from 81 plots in 27 forest cover polygons in the Boreal Foothills Natural Disturbance Unit (DeLong 2002). The 27 stands were located in the Finlay-Peace variant of the wet cool Sub-Boreal Spruce (SBSwk2) subzone (DeLong 2004), and in the Bullmoose variant of the moist very cold subzone and the Misinchinka variant of the wet cool subzone of the Engelmann Spruce–Subalpine Fir zone (ESSFmv2 and ESSFwk2, respectively) (MacKinnon et al. 1990; DeLong et al. 1994).

In each forest polygon, three plots were sampled, including detailed site descriptions (B.C. Ministry of Forests and B.C. Ministry of Environment, Lands and Parks 1998). Plots were located at the centre of three 100-m transects. The first transect was laid out at a random azimuth from a point at least 100 m from the stand edge. Each successive transect was laid out from the end of the previous transect at a random azimuth, with no point along a transect within < 30 m of a stand edge. A nested plot design was used with an inner radius of 11.28 m (0.04 ha) and an outer radius of 17.84 m (0.1 ha). Trees and snags > 7.5 cm dbh were measured in the inner plot, while a diameter limit of 30 cm was set for the outer plot. Densities of trees measured in inner and outer plots were separately standardized in per-hectare units using the appropriate plot expansion factors and then combined.

The tree species sampled were black cottonwood, trembling aspen, subalpine fir, paper birch, lodgepole pine, black spruce, and white spruce. A total of 5797 trees were sampled in this study (Table 2).

2.1.3 SBS study Mixed conifer forests in the moist interior were surveyed by collecting data from 50 plots in 17 forest stands within the Moist Interior Plateau Natural Disturbance Unit (DeLong 2002). Stands were located in the dry cool (SBSdk), the Stuart variant of the dry warm (SBSdw3), the Babine and Kluskus variants of the moist cold (SBSmc2, SBSmc3), and the Mossvale variant of the moist cool (SBSmk1) subzones of the SBS zone (DeLong et al. 1993).

The sampling protocol followed that of the Boreal Old-Growth Study (section 2.1.2), with the exception of the outer plot tree diameter limit, which was set at 20 cm instead of 30 cm.

The tree species sampled were black cottonwood, trembling aspen, paper birch, subalpine fir, Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Mirb.) Franco), lodgepole pine, black spruce, and hybrid white spruce. A total of 4491 trees were sampled in this study (Table 2).

2.1.4 ICH study For the wettest ecosystem sampled, data were collected from 45 plots in 15 zonal sites located in the moist mild subzone of the of the Interior Cedar-Hemlock (ICHmm) BEC zone (DeLong and Meidinger 1996).

Sampling procedures followed those of the Boreal Old-Growth Study (section 2.1.2), except that all trees > 7.5 cm dbh were measured using the entire 0.1-ha plot.

The tree species sampled were black cottonwood, trembling aspen, paper birch, subalpine fir, western redcedar, Douglas-fir, western hemlock, lodgepole pine, and hybrid white spruce. A total of 2899 trees were sampled in this study (Table 2).

2.2 Data analysis

2.2.1 Midpoint diameter class Trees were initially placed in 5-cm midpoint diameter classes and then these classes were lumped (Table 3) for analysis

based on tree diameter requirements for merchantable timber utilization in British Columbia and for wildlife species requirements as defined by Keisker (2000). The general merchantability limit of 17.5 cm dbh established by the B.C. Ministry of Forests and Range for most species (B.C. Ministry of Forests and Range 2007a) defines the upper limit for the smallest class. Thus the trees 7.5–12.4 cm dbh (10-cm midpoint) and the trees 12.5–17.4 cm dbh (15-cm midpoint) were assigned to the smallest class. Subsequent classes for trembling aspen and paper birch were defined as follows: midpoint classes 20–25 cm (17.5–27.4 cm) (above merchantable size but not large enough for WT1 and WT2), midpoint classes 30–40 cm (27.5–42.4 cm) (minimum size requirement for WT1 but not large enough for Pileated Woodpecker), and 45+ cm (42.5+ cm) (minimum size for WT1, Pileated Woodpecker). The midpoint diameter classes used for all other tree species are: 20–35 cm midpoint classes (17.5–37.4 cm) (above merchantable size but not large enough for WT1), 40–50 cm midpoint classes (37.5–53.4 cm) (minimum size requirement for WT1), and 55+ cm (53.5+ cm) (minimum size for WT1, Pileated Woodpecker).

TABLE 3 *Lumped 5-cm midpoint diameter classes used for compiling results of study*

Tree species	Class (cm)	Range (cm)
All	10–15	7.5–17.4
At, Ep	20–25	17.5–27.4
	30–40	27.5–42.4
	45+	≥42.5
Act, Bl, Cw, Fd, Hw, Pl, Sb, Sx	20–35	17.5–37.4
	40–50	37.5–53.4
	55+	≥53.5

2.2.2 Occurrence of live versus dead stems The proportion of live versus dead stems was calculated for each species, lumped by midpoint diameter class combination for each study. These proportions were determined by dividing the number of live and dead stems for each diameter class by the total number of stems (live and dead) within that class.

2.2.3 Occurrence of Wildlife Tree types by tree species, study area, and diameter class The relationships between tree species, tree diameter, and functional WT types were presented in tabular form for each of the four study areas. The relationship was determined by calculating the proportion (%) of a tree species (live and dead separately) in each lumped midpoint diameter class that displayed each of the 10 WT types. Individual studies were compiled separately, and differences between species, diameter class, and study area were compared. Tree species were not included in the analysis if the sample was deemed too small or if the species did not display any WT types.

2.2.4 Provincial Wildlife Tree ranking To provide a link to Provincial WT Policy (B.C. Ministry of Forests 2000), individual WT value was ranked as low, medium, or high using the adapted guidelines listed in Table 4. In order to demonstrate the overall contribution of individual tree species to wildlife value, the frequency of occurrence (%) of each tree species for all studies

TABLE 4 *Adapted ranking of Wildlife Tree value according to provincial Wildlife Tree policy (B.C. Ministry of Forests 2000)*

Wildlife Tree Value	Characteristics	Adapting to WT types (Keisker 2000)
High A high-value wildlife tree has at least two of the characteristics listed in the adjacent column.	• Internal decay (heart rot or natural/ excavated cavities present) • Crevices present (loose bark or cracks suitable for bats) • Large brooms present • Active or recent wildlife use • Current insect infestation • Tree structure suitable for wildlife use (e.g., large nest, hunting perch, bear den) • Largest trees on site (height and/or diameter) and/or veterans • Locally important Wildlife Tree species	Displays two or more WT types
Medium	• Large, stable trees that will likely develop two or more of the above attributes for High category	Displays one WT type
Low	Trees not covered by High or Medium categories	

combined is presented for low, medium, and high provincial WT rankings by dead and live stems. Only the species analyzed in section 2.2.2 were included.

2.2.5 Density of Wildlife Tree types per hectare by ecosystem/study area The functional WT types presented provide resource managers with a practical means of estimating potential habitat value across a variety of ecosystems. In order for this information to be applied and interpreted across the landscape, spatial units are necessary. To allow for this interpretation, WT types and mean values (including standard errors) were calculated for each study area and presented in per-hectare units.

3 RESULTS

3.1 Occurence of live versus dead stems

When all species and lumped midpoint diameter classes were considered, the ratio of live versus dead stems was fairly consistent between studies (Table 5). Stems in the largest diameter classes (55+ cm and 45+ cm) were consistently present only in the ICH study for all species, and for spruce in the Boreal study. The number of dead stems for seral species (i.e., black cottonwood, trembling aspen, and lodgepole pine) increased substantially in the smaller diameter classes, while for climax or long-lived seral species the increase was less apparent (Table 5).

TABLE 5 *Total numbers and ratios of live versus dead stems by lumped midpoint diameter class for the Aspen, Boreal, SBS, and ICH study areas*

		Aspen OG Study			Boreal OG Study			SBS OG Study			ICH OG Study		
Tree species	Mid-point dia. class	Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)
Act (black cottonwood)	10–15 cm	271	410	1.5	0	1	1/0	-	-	-	2	4	2.0
	20–35 cm	224	889	4.0	-	-	-	1	4	4.0	2	14	7.0
	40–50 cm	11	103	9.4	0	1	1/0	0	3	3/0	2	2	1.0
	55+ cm	0	8	8/0*	-	-	-	-	-	-	-	-	-
	Total	506	1410	2.8	0	2	2/0	1	7	7.0	6	20	3.3
At (trembling aspen)	10–15 cm	405	861	2.1	23	10	0.4	9	36	4.0	15	12	0.8
	20–25 cm	99	1321	13.3	4	4	1.0	14	38	2.7	5	25	5.0
	30–40 cm	26	867	33.3	4	28	7.0	1	25	25.0	3	16	5.3
	45+ cm	3	73	24.3	0	5	5/0	0	3	3/0	0	3	3/0
	Total	533	3122	5.9	31	47	1.5	24	102	4.3	23	56	2.4
Ep (paper birch)	10–15 cm	4	26	6.5	-	-	-	1	6	6.0	0	8	8/0
	20–25 cm	6	11	1.8	-	-	-	0	1	1/0	4	7	1.8
	30–40 cm	1	1	1.0	-	-	-	0	2	2/0	0	3	3/0
	45+ cm	-	-	-	-	-	-	-	-	-	-	-	-
	Total	11	38	3.5	-	-	-	1	9	9.0	4	18	4.5
Bl (subalpine fir)	10–15 cm	0	6	6/0	269	1113	4.1	9	38	4.2	77	74	1.0
	20–35 cm	0	1	1/0	134	448	3.3	9	36	4.0	33	62	1.9
	40–50 cm	-	-	-	11	40	3.6	1	0	0/1	6	7	1.2
	55+ cm	-	-	-	0	2	2/0	-	-	-	3	0	0/3
	Total	0	7	7/0	414	1603	3.9	19	74	3.9	119	143	1.2
Cw (western redcedar)	10–15 cm	-	-	-	-	-	-	-	-	-	46	200	4.3
	20–35 cm	-	-	-	-	-	-	-	-	-	44	308	7.0
	40–50 cm	-	-	-	-	-	-	-	-	-	16	114	7.1
	55+ cm	-	-	-	-	-	-	-	-	-	16	185	11.6
	Total	-	-	-	-	-	-	-	-	-	122	807	6.6

TABLE 5 *Continued*

Tree species	Mid-point dia. class	Aspen OG Study			Boreal OG Study			SBS OG Study			ICH OG Study		
		Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)	Dead stems	Live stems	Ratio (L/D)
Fd (Douglas-fir)	10–15 cm	-	-	-	-	-	-	-	-	-	10	59	5.9
	20–35 cm	-	-	-	-	-	-	0	3	3/0	4	211	52.8
	40–50 cm	-	-	-	-	-	-	0	3	3/0	3	17	5.7
	55+ cm	-	-	-	-	-	-	0	1	1/0	3	13	4.3
	Total	-	-	-	-	-	-	0	7	7/0	20	300	15.0
Hw (western hemlock)	10–15 cm	-	-	-	-	-	-	-	-	-	36	201	5.6
	20–35 cm	-	-	-	-	-	-	-	-	-	35	391	11.2
	40–50 cm	-	-	-	-	-	-	-	-	-	16	151	9.4
	55+ cm	-	-	-	-	-	-	-	-	-	15	92	6.1
	Total	-	-	-	-	-	-	-	-	-	102	835	8.2
Pl (lodgepole pine)	10–15 cm	16	22	1.4	210	393	1.9	336	908	2.7	1	2	2.0
	20–35 cm	13	127	9.8	116	804	6.9	136	1426	10.5	4	55	13.8
	40–50 cm	2	32	16.0	5	105	21.0	2	71	35.5	1	5	5.0
	55+ cm	0	2	2/0	0	1	1/0	-	-	-	0	1	1/0
	Total	31	183	5.9	331	1303	3.9	474	2405	5.1	6	63	10.5
Sb (black spruce)	10–15 cm	1	31	31.0	58	175	3.0	48	240	5	-	-	-
	20–35 cm	1	18	18.0	22	86	3.9	16	91	5.7	-	-	-
	40–50 cm	-	-	-	1	2	2.0	0	2	2/0	-	-	-
	55+ cm	-	-	-	-	-	-	-	-	-	-	-	-
	Total	2	49	24.5	81	263	3.2	64	333	5.2	-	-	-
Sx (spruce)	10–15 cm	9	83	9.2	79	380	4.8	74	471	6.4	17	23	1.4
	20–35 cm	5	88	17.6	76	671	8.8	26	372	14.3	22	154	7.0
	40–50 cm	1	25	25.0	44	397	9.0	2	25	12.5	5	23	4.6
	55+ cm	0	4	4/0	5	70	14.0	0	1	1/0	2	8	4.0
	Total	15	200	13.3	204	1518	7.4	102	869	8.5	46	208	4.5
Total of all species		1098	5009	4.6	1061	4736	4.5	685	3806	5.6	448	2450	5.5

* Entries consisting of 'x'/o represent categories that had no trees in either the live or dead categories.

3.2 Occurrence of Wildlife Tree types by tree species, study area, and diameter class

The ICH study found all 10 of the WT types and the Aspen study found nine (Figure 2, Appendix 2), while the SBS and Boreal studies found seven and five of the WT types, respectively (Figure 2, Appendix 2). WT4, WT5, and WT10 were the least observed types across all studies and were most often recorded for western redcedar and western hemlock in the ICH study, and trembling aspen and black cottonwood in the Aspen study (with the exception that no WT5 were observed in the Aspen study). WT1 and to a lesser extent WT6, 8, and 9 were more abundant and occurred on the greatest range of tree species across all studies, while WT5 occurred only in the ICH study. In the Aspen and SBS studies, WT2 was observed only on deciduous tree species, while in the ICH it was observed on western redcedar and western hemlock as well. WT7 was observed primarily in the Boreal and SBS studies on spruce and lodgepole pine (Figure 2, Table 6, Appendix 2).

Based on all data combined, dead large-diameter trees have a higher frequency of displaying one or more WT types than do live trees. Western redcedar and western hemlock each displayed nine of the 10 potential WT types, followed by black cottonwood, and trembling aspen, both of which displayed eight different WT types. All WT types except WT10 are most abundant in the three largest lumped midpoint diameter classes (40-50cm, 45+ cm and 55+ cm or with diameters > 37.5 cm), and (aside from WT7) occur mostly on dead stems (Figure 3, Appendices 3a and 3b).

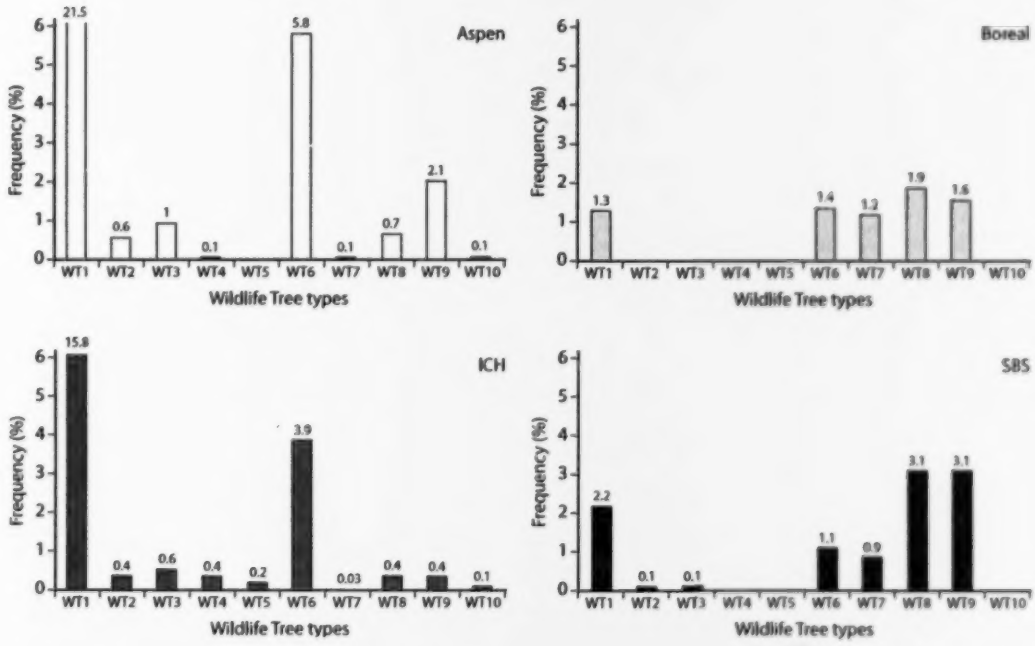

FIGURE 2 *Percent available Wildlife Tree types (Keisker 2000) for all tree species, live and dead, combined by study site.*

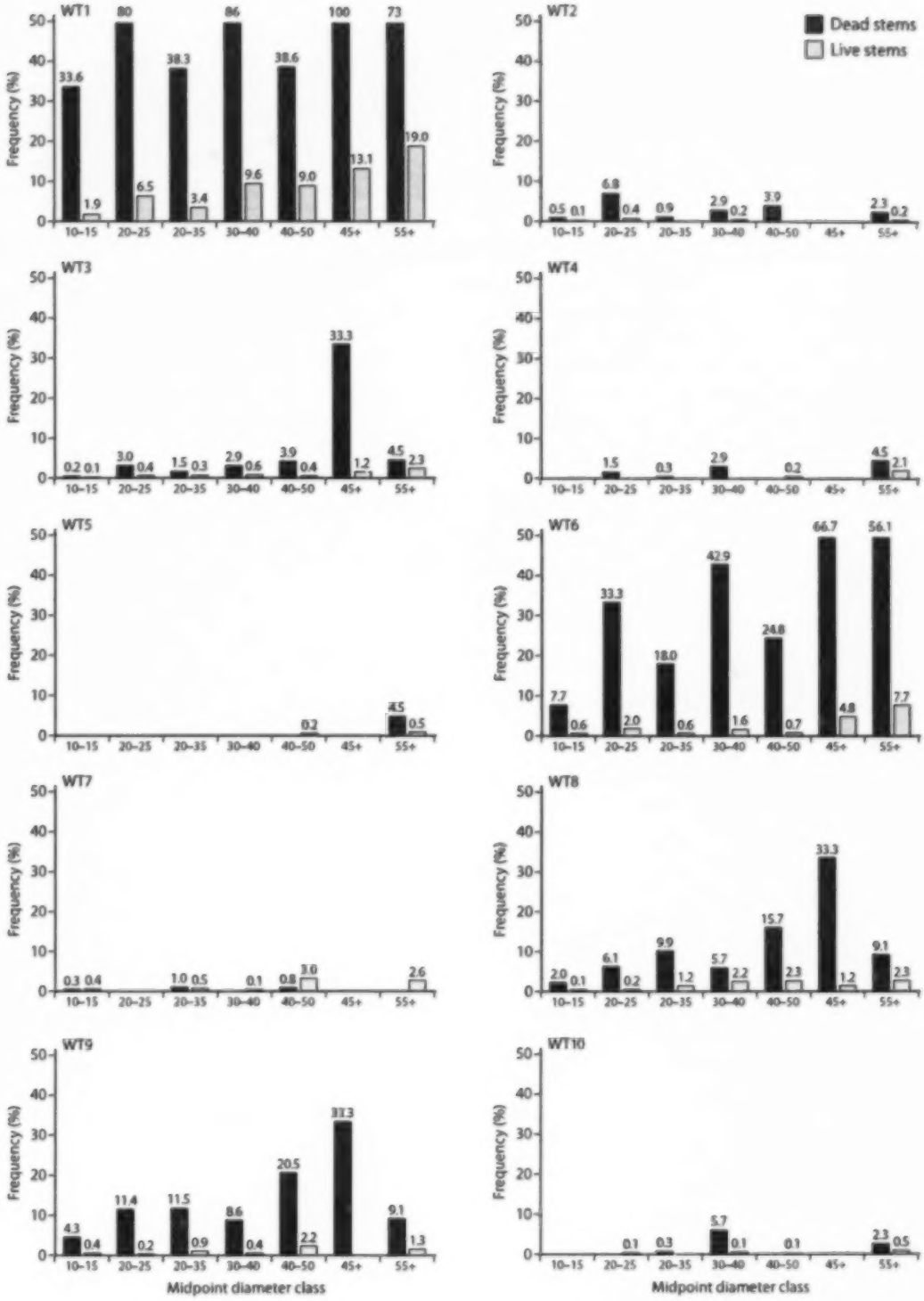

FIGURE 3 *Frequency of occurrence (%) for each wildlife type on dead and live stems by midpoint diameter class for all stems from all studies combined.*

TABLE 6 *Summary of Wildlife Tree types associated with each tree species in each study listed from most to least abundant (see Table 1 for explanation of Wildlife Tree types)*

Tree species	Aspen OG Study	Boreal OG Study	SBS OG Study	ICH OG Study
Act (black cottonwood)	1,6,3,9,8,2,4,10	*	1,3,6,8*	1,6*
At (trembling aspen)	1,6,9,8,3,2,10,4	1,8,6,9	1,6,8,2,3	1,6,2
Ep (paper birch)	1,2,6,9	n/a	8,1,2,6,9*	1,6*
Bl (subalpine fir)	n/a	6,1,8,7,9,3	6,9,1	1,6
Cw (western redcedar)	n/a	n/a	n/a	1,6,3,2(4,8),5,(9,10)
Fd (Douglas-fir)	n/a	n/a	9*	1,6
Hw (western hemlock)	n/a	n/a	n/a	1,6,9(4,8),2(3,5),10
Pl (lodgepole pine)	1,6,9,3,8	8,6,9,1,7	9,8,6,1,7,3	1,6
Sb (black spruce)	1,7	9,7,8	9,1,7,8,6	n/a
Sx (spruce)	1,9,6,7,8	9,1,8,7,6,3	9,1,8,7,6,3	1,9,10

n/a = none sampled; ( ) = all have = weight; * = small sample size

3.3 Provincial Wildlife Tree ranking

For snags, across all studies, the greatest percentage of trees ranked as having high WT value was seen in the two largest lumped midpoint diameter classes, with the exception of paper birch (Figure 4, Appendix 4). For live trees this trend was not as clear. Those that clearly followed the same trend as the snags were paper birch, western redcedar, western hemlock, and hybrid/white spruce. For trembling aspen, subalpine fir, Douglas-fir, lodgepole pine, and black spruce, a higher percentage of the larger-diameter trees was given a medium ranking (Figure 4, Appendix 4). When all studies were combined, high-value trees (> 1 WT type) occurred most frequently for broadleaf trees—black cottonwood, paper birch, and trembling aspen at 9.1, 7.4, and 5.4%, respectively (Figure 5, Appendix 5). The highest-ranked conifers were western redcedar and western hemlock at 4.0 and 3.0% high-value trees, respectively. Paper birch, western hemlock, and black cottonwood were the most frequently ranked as medium value at 27.2, 26.3 and 23.5%, respectively (Figure 5, Appendix 5).

3.4 Density of Wildlife Tree types per hectare by study area

Abundance of individual WT types amongst study areas differed considerably (Figure 6, Appendix 6); many types occurred at less than 10 sph. Percentages of trees having no types present by study area were Aspen study = 76%, Boreal study = 94%, ICH study = 82%, and SBS study = 91%. Frequencies of trees (sph) across all studies having one or more WT types present are shown in Figure 6 and Appendix 6. Trees having one WT type present occurred with the greatest frequency in the ICH and Aspen studies. These studies were also the only studies where trees demonstrated four or five WT types.

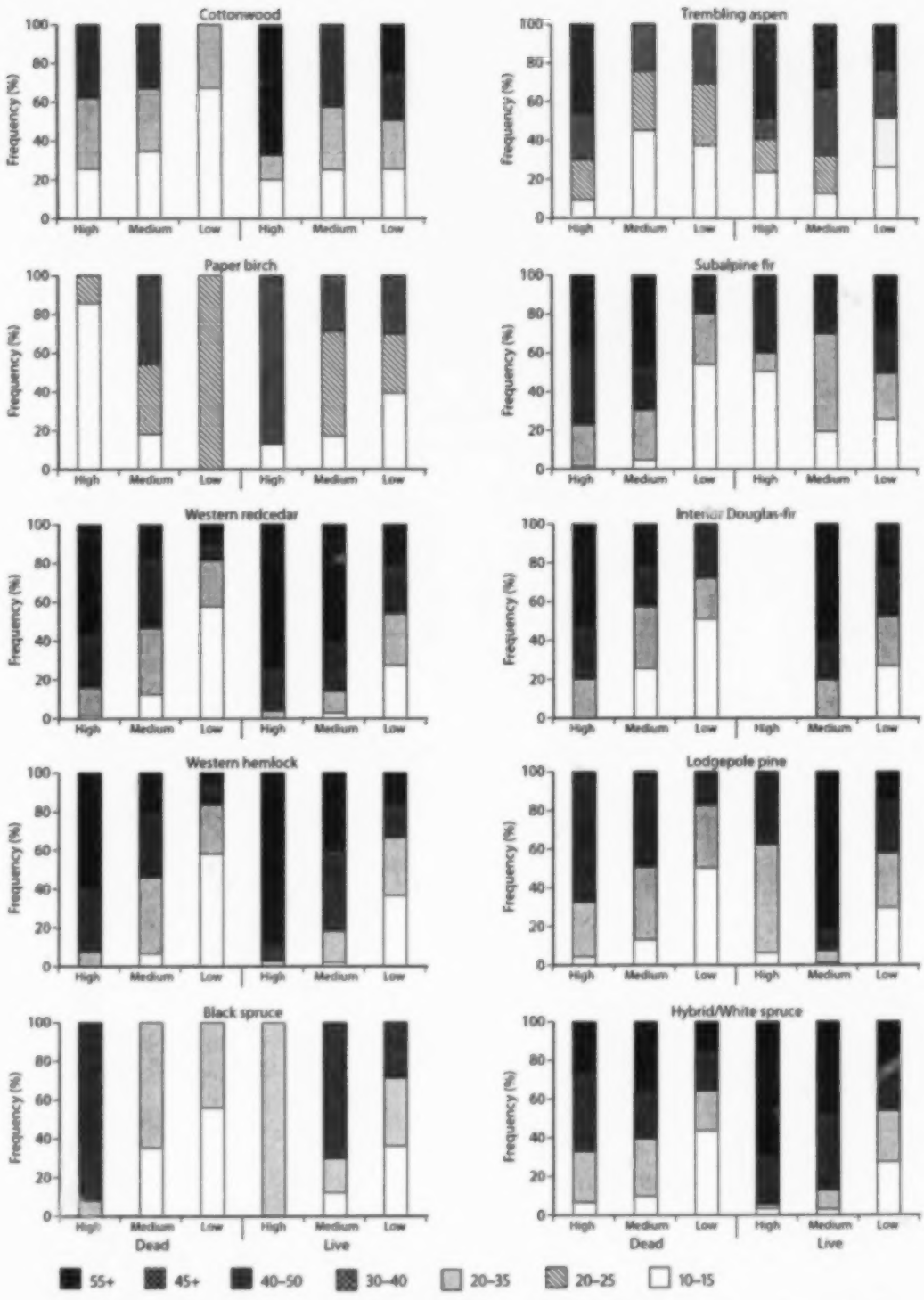

FIGURE 4 *Frequency of occurrence (%) for stems in each midpoint diameter class occurring in High, Medium and Low wildlife value ranking categories by tree species as per provincial Wildlife Tree policy (see Table 4) for all studies combined.*

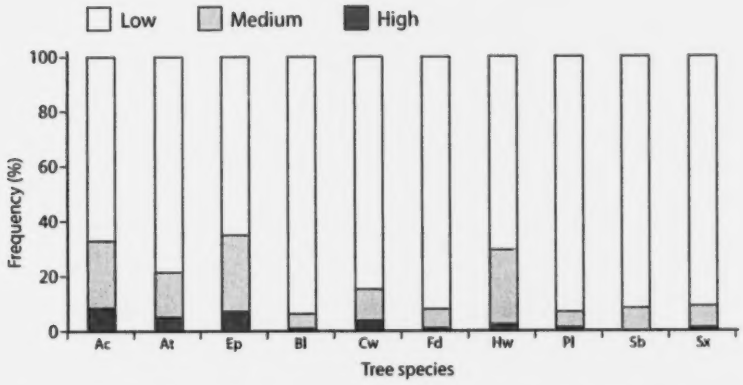

FIGURE 5 *Relative frequency of occurrence of trees ranked as per the provincial Wildlife Tree policy categories for High, Medium, and Low wildlife value by tree species for all studies combined.*

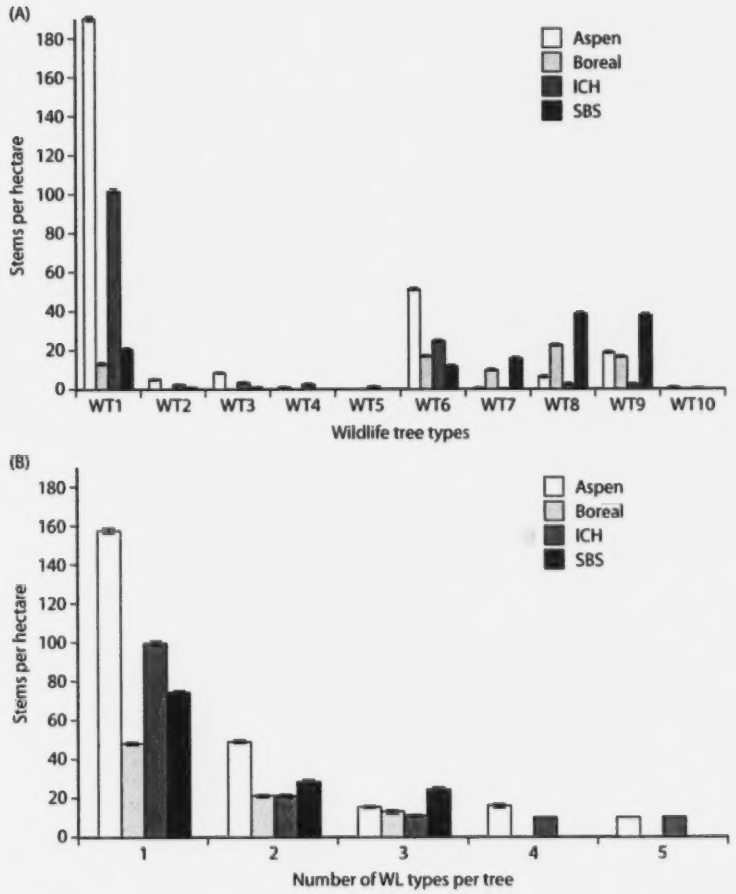

FIGURE 6 *Abundance (mean stems/ha and standard error of the mean) of specific Wildlife Tree types (A), and trees having one or more Wildlife Tree type (B), for the Aspen, Boreal, ICH, and SBS studies.*

The higher comparative habitat value of certain tree species (i.e., black cottonwood, trembling aspen, western redcedar, and western hemlock) observed in these four studies has also been cited by others (Bull et al. 1997; Bunnell et al. 1999), and can be attributed to a set of distinct characteristics such as deeply furrowed bark, large branches, hollow centres, and associated decay agents (Wildlife Tree Committee of British Columbia 2001). These researchers also note that hardwoods (i.e., black cottonwood and trembling aspen) are often preferred by cavity nesters (Bull et al. 1997; Bunnell et al. 1999); however, hardwood species generally start decaying at smaller diameters and younger ages than conifers, resulting in accelerated fall-down rates (Wildlife Tree Committee of British Columbia 2001). In interior ecosystems, this results in large birds often using large-diameter conifers (i.e., western redcedar and western hemlock) that provide appropriate cavities (Bunnell et al. 1999). Each of these four tree species (black cottonwood, trembling aspen, western redcedar, and western hemlock) also tend to be the largest trees surveyed in each study area, in many cases facilitating WT4 and WT5 (medium and large cavities, respectively), which require larger diameters. The relationship between functional wildlife habitat types and larger diameters (such as those presented in Table 5, Figure 3, and Appendices 3a and 3b within the 45+ cm and 55+ cm midpoint diameter class) has also been observed in a number of other studies (Mannon et al. 1980; Machmer and Steeger 1995; Bunnell et al. 1999; Stevenson et al. 2006).

Differences in the distribution of WT rankings in relation to diameter class and live or dead status demonstrate the importance of size and condition with respect to relative habitat value. As seen in the WT ranking (Figure 4, Appendix 4), larger-diameter snags in general tend to have higher WT value for almost all species examined. In contrast, only half of the live trees displayed higher ranking for trees in larger diameter classes (as seen for subalpine fir, where very few observations were seen for high ranking, and only in the smallest diameter class). Western redcedar, hybrid/white spruce, and western hemlock can persist and grow larger than other species (such as black spruce, trembling aspen, and lodgepole pine) while possessing some of the previously mentioned important characteristics (such as internal decay of heartwood) and thus provide a greater wildlife habitat contribution in the largest class. However, "low-value" species should not be ignored. For example, the finding of subalpine fir as the least valuable WT can be misleading. Subalpine fir may not rank highly compared to other species examined in this study, but with the loose raised bark that forms on the bole shortly after mortality it is a significant contributor to bat habitat (WT6). It may not contribute significantly to the proportion of all WT types but may be key to the maintenance of bat habitat in some areas. When managing for specific wildlife species, the ranking of the particular types important for that species must be considered.

The finding of a lower number of WT types in the Boreal study, even though it had the highest proportion of dead stems (18.4%) and a significant amount of large-diameter trees, can be explained by the tree species present and the proportion of each species present. The two most abundant species in the Boreal study were subalpine fir (35%) and white spruce (30%). Subalpine

fir was found to be the "least valuable" WT, and white spruce was not ranked much higher. In contrast, the Aspen study had only 18% dead stems, but was dominated by trembling aspen (59%) and black cottonwood (31%), two of the most valuable WTs in the study. This finding emphasizes the importance of tree species to functional WT classification results.

Size clearly matters when trees are evaluated for WT value according to the provincial WT ranking system (Table 4, Figure 4). For snags and live trees the highest rankings generally occurred in the largest two diameter classes associated with a particular species. The ranking needs to be scaled for some species due to their relative growth rates. The general finding that large-diameter snags tend to provide more value as WTs is supported by many other studies (Steeger et al. 1993; Bunnell et al. 1999; Ganey 1999; Marcot 2002; Waterhouse et al. 2002; Stevenson et al. 2006). Species such as paper birch and black spruce did not contribute live or dead trees to the largest diameter class but still substantially contributed trees ranked with high value in the live category (for paper birch) and in the dead category (for black spruce). This emphasizes the need for fine-filter approaches such as the acquisition of geographically specific functional WT type data that can be used in conjunction with the provincial WT ranking system to identify WT habitat value at the species level, and help improve ecologically specific landscape-level modelling projections.

Some similarities and differences of WT occurrence in the ICHmm were found when compared to observations by Stevenson et al. (2006) for the ICHwk3 and vk2 (Goat wet cool and Slim very wet cool) BEC variants. In both studies, WT1 and WT6 were the most common types observed when all trees were combined. However, for the ICHmm study, WT1 occurred almost five times more frequently than for the ICHwk3 and vk2 study (102 sph versus approximately 22 sph, respectively), and WT6 occurred only half as much in the ICHmm study as in the ICHwk3 and vk2 study (25 sph versus approximately 45 sph). The differences seen between these ecosystems could be explained by species composition and disturbance agents. Indian Paint Fungus (*Echinodontium tinctorium* (Ellis & Everh.) Ellis & Everh.) is one of the most common heartrot fungi occurring in this geographic location (Stevenson et al. 2006) and is associated primarily with western hemlock (Henigman et al. 2001). In the ICHmm, western hemlock made up more than 32% of the stems surveyed versus less than 10% in the ICHwk3 and vk2 study. WT1 is associated with decay-softened inner wood or heartrot. Thus, western hemlock's susceptibility to heartrot and greater abundance in the ICHmm study area could explain the higher occurrence of WT1. The realization of these relative similarities and differences emphasizes the importance of understanding the relationships between tree species composition, disease susceptibility, and disturbance agents in dictating habitat attribute availability at the ecosystem and/or site level. Structurally, wildlife habitat associated with standing trees is often related to those with larger diameters. However, smaller trees, often dead due to suppression or stem exclusion (Smith et al. 1997), also contribute as feeding substrate for insects, which are important prey for many bird species (Cline et al. 1980). In this study, the highest proportion of dead stems for most species was found in the smallest midpoint diameter class (Table 5). Mid-seral forests have been observed to contain fewer smaller snags than later-seral forests (Korol et al. 2002); thus, for snag management, species composition as well as seral stage distribution should be considered

The rarity of very large (i.e., > 52.5 cm) stems in the SBS, Aspen, and Boreal studies compared to the ICH study (Table 5) is due in part to disturbance history and tree species composition. Stand replacement disturbance is more frequent on dry to moist boreal and sub-boreal landscapes (which include the Aspen, Boreal, and SBS study areas) than for the wetter ICH forests (DeLong 1998; Wong et al. 2003). The result of this temporal difference in disturbance is more younger trees and often more seral species in drier landscapes, compared with more older trees and more climax tree species in the wetter landscapes. Relative growth rates also play a role in the abundance of larger trees and thus larger snags. Trembling aspen and black cottonwood have high growth rates compared to conifer trees and thus have the potential to produce large trees and snags. This is supported by observations in the Aspen study of a high component of live and dead aspen in the larger diameter class (Table 5). Although Douglas-fir's contribution to wildlife habitat attributes was not seen to be substantial in these studies as a result of its low occurrence in the chosen study areas, it is considered a valuable WT species (Whittaker 1996) in localized drier ecosystems at the northern extent of its range, where it occurs in a fragmented patchy distribution throughout the SBS (DeLong 1999). Due to its thick fire-resistant bark it survives frequent wildfires and therefore grows to old ages and large sizes, providing a unique larger, older structural component to otherwise younger seral stands.

Tree species susceptibility and the suitability of wetter ecosystems to fungal pathogens had a major influence on the abundance of WT types found on western redcedar and western hemlock in the ICH study. Of the 10 WT types present on these tree species, WT1, 2, 3, 4, 5, and 8 could all be associated with heartrot and/or loss of inner structural integrity. In western hemlock, this can be largely attributed to infection from *E. tinctorium*, and most mature western redcedar trees in the northern ICH are internally decayed or hollow at stump height (Stevenson et al. 2006). As shown in Figure 2, WT4 and 5 occurred most often in the ICH, the wettest of the ecosystems sampled in this study. The presence of both WT4 (large excavated or natural cavities) and WT5 (very large natural cavities and hollow trees) (Keisker 2000) is very much reliant on heartrot fungi to create soft inner substrate that can be utilized by cavity excavators. WT10 hunting perches, seen only in the ICH and Aspen studies, require adjacency to unforested areas, forest openings, or sparse tree layers (Keisker 2000). These features are associated with uneven-aged stands in relatively wetter ecosystems such as the ICH zone (Meidinger and Pojar. 1991) that have many canopy gaps, or in older aspen forests where gaps are being created by very old aspen falling out of the canopy.

5 CONCLUSIONS

Forest management decisions are rarely based directly on an understanding of the mechanisms that influence the presence and longevity of WT habitat attributes. Instead, forest managers require information on how the occurrence of these features is related to easily measured attributes such as diameter and tree species (Stevenson et al. 2006). With the use of functional WT types (Keisker 2000) and a WT ranking system (B.C. Ministry of Forests 2000), we have demonstrated a practical method for obtaining ecosystem-specific information.

When considering all four ecosystems studied as a whole, black cottonwood, trembling aspen, western redcedar, and western hemlock snags provide the most diverse wildlife habitat. Forested ecosystems that include these species may inherently be of higher importance for inclusion within reserves. Larger-diameter stems, especially when dead, tend to provide higher-quality habitat, so there is a need to somehow provide larger-diameter snags, likely by means of reserving dispersed or aggregated larger stems during harvest. It is still important to understand how the abundance of trees of all species and sizes with varying functional habitat values differs amongst ecosystems and changes with time, in order to focus on reserving trees with rarer habitat values within a particular ecosystem. Furthermore, understanding the key processes that maintain the different habitat functions of trees *in situ* is critical so that we may apply this knowledge to forest management.

Many ecological functions, other than the habitat structures linked directly with live and dead trees, are associated with the natural levels of tree sizes and wood decay, such as organic matter input to soils, nutrient cycling, and nurse structures for plants (Marcot 2002). Maintaining these functions and their influence on tree species composition, establishment, growth rates, and mortality rates contributes directly or indirectly to the rejuvenation of natural forest structure following natural or anthropogenic disturbance. This meta-analysis demonstrates the natural range of variability for WT types and their associated structural elements within differing landscapes, and provides a basis for geographically specific modelling and subsequent establishment of management targets for these elements.

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APPENDIX 1 Identified Wildlife or Species at Risk in the Identified Wildlife Management Strategy (IWMS) of the *British Columbia Forest and Range Practices Act* requiring "Special Management Attention" (IWMS 2004)

Name		Wildlife Tree requirement
Flammulated Owl	*Otus flammeolus idahoensis*	Nesting and/or roosting
Great Blue Heron	*Ardea herodias fannini*	
Lewis's Woodpecker	*Melanerpes lewis*	
Marbled Murrelet	*Brachyramphus marmoratus*	
"Queen Charlotte" Goshawk	*Accipiter gentillis laingi*	
Spotted Owl	*Strix occidentalis*	
"Interior" Western Screech-owl	*Otus kennicottii macfarlanei*	
White-headed Woodpecker	*Picoides albolarvatus*	
Keen's long-eared myotis	*Myotis keenii*	
Fringed myotis	*Myotis thysanodes*	
Grizzly bear	*Ursus arctos*	Large diameter for denning
Red-legged frog	*Rana aurora*	Habitat enhanced when retained
Coastal giant salamander	*Dicamptodon tenebrosus*	
Coeur d'Alene salamander	*Plethodon idahoensis*	
Pacific water shrew	*Sorex bendirii*	
Badger	*Taxidea taxus jeffersonii*	
Spotted bat	*Euderma maculatum*	

APPENDIX 2 Data for Figure 2: Percentage of available Wildlife Tree types (Keisker 2000) for all tree species, live and dead, combined by study site.

	WT Type									
Species	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	WT9	WT10
Aspen	21.50	0.60	1.00	0.10	0.00	5.80	0.10	0.70	2.10	0.10
Boreal	1.30	0.00	0.00	0.00	0.00	1.40	1.20	1.90	1.60	0.00
ICH	15.80	0.41	0.55	0.41	0.21	3.86	0.03	0.41	0.41	0.10
SBS	2.20	0.10	0.10	0.00	0.00	1.10	0.90	3.10	3.10	0.00

APPENDIX 3a Data for Figure 3: Frequency of occurrence (%) for each Wildlife Tree type (Keisker 2000) on dead (D) and live (L) stems by midpoint diameter class for all Stems from all studies combined.

	Mid-point diameter class													
	10–15		20–25		20–35		30–40		40–50		45+		55+	
WT type	D	L	D	L	D	L	D	L	D	L	D	L	D	L
WT1	33.6	1.9	79.5	6.5	38.3	3.4	85.7	9.6	38.6	9.0	100.0	13.1	72.7	19.0
WT2	0.5	0.1	6.8	0.4	0.9	0.0	2.9	0.2	4.1	0.0	0.0	0.0	2	0
WT3	0.2	0.1	6.8	0.4	1.5	0.3	2.9	0.6	4.1	0.4	33.3	1.2	4.9	2.3
WT4	0.0	0.0	1.5	0.0	0.3	0.0	2.9	0.0	0.0	0.2	0.0	0.0	4.9	2.1
WT5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	4.9	0.5
WT6	7.7	0.6	33.3	2.0	18.0	0.6	42.9	1.6	24.4	0.7	66.7	4.8	56.1	7.7
WT7	0.3	0.4	0.0	0.0	1.0	0.5	0.0	0.1	0.8	3.0	0.0	0.0	0.0	2.6
WT8	2.0	0.1	6.1	0.2	9.8	1.2	5.7	2.2	16.5	2.3	33.3	1.2	9.8	2.3
WT9	4.3	0.4	11.4	0.2	11.4	0.9	8.6	0.4	21.5	2.2	33.3	0.0	9.8	1.3
WT10	0.0	0.0	0.0	0.1	0.3	0.0	5.7	0.1	0.0	0.1	0.0	0.0	2.4	0.5

APPENDIX 3b Frequency of occurrence (%) for each Wildlife Tree Type (Keisker 2000) by ecosystem (study) and tree species (dead and live).

Study	Species	Live/Dead	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	WT9	WT10	*n*
Aspen	Act	D	91	2	2	1	0	22	0	3	8	0	506
Aspen	Act	L	7	0	2	0	0	3	0	0	1	0	1410
Aspen	At	D	92	2	2	1	0	23	0	2	9	0	533
Aspen	At	L	6	0	0	0	0	2	0	1	0	0	3122
Aspen	Bl	D	0	0	0	0	0	0	0	0	0	0	0
Aspen	Bl	L	0	0	0	0	0	0	0	0	0	0	7
Aspen	Ep	D	55	36	0	0	0	27	0	0	0	0	11
Aspen	Ep	L	18	0	0	0	0	0	0	0	8	0	38
Aspen	Pl	D	94	0	0	0	0	16	0	0	19	0	31
Aspen	Pl	L	1	0	1	0	0	0	0	1	3	0	183
Aspen	Sb	D	50	0	0	0	0	0	0	0	0	0	2
Aspen	Sb	L	2	0	0	0	0	0	4	0	0	0	49
Aspen	Sx	D	87	0	0	0	0	7	0	0	27	0	15
Aspen	Sx	L	1	0	0	0	0	0	1	1	2	0	200
Boreal	Act	D	0	0	0	0	0	0	0	0	0	0	0
Boreal	Act	L	0	0	0	0	0	0	0	0	0	0	2
Boreal	At	D	10	0	0	0	0	6	0	10	0	0	31
Boreal	At	L	15	0	0	0	0	0	0	0	2	0	47
Boreal	Bl	D	4	0	0	0	0	12	0	6	1	0	414
Boreal	Bl	L	1	0	0	0	0	0	0	0	0	0	1603
Boreal	Pl	D	2	0	0	0	0	8	0	9	2	0	331
Boreal	Pl	L	0	0	0	0	0	0	0	0	0	0	1303
Boreal	Sb	D	0	0	0	0	0	0	2	2	15	0	81
Boreal	Sb	L	0	0	0	0	0	0	2	0	0	0	263
Boreal	Sx	D	10	0	0	0	0	2	1	15	16	0	204
Boreal	Sx	L	1	0	0	0	0	0	3	1	2	0	1518

Study	Species	Live/Dead	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	WT9	WT10	*n*
ICH	Act	D	25	0	0	0	0	25	0	0	0	0	4
ICH	Act	L	14	0	0	0	0	0	0	0	0	0	22
ICH	At	D	35	4	0	0	0	9	0	0	0	0	23
ICH	At	L	20	0	0	0	0	2	0	0	0	0	56
ICH	Bl	D	27	0	0	0	0	10	0	0	0	0	119
ICH	Bl	L	1	0	0	0	0	1	0	0	0	0	143
ICH	Cw	D	37	4	3	0	0	31	1	0	1	1	122
ICH	Cw	L	5	0	1	1	0	4	0	1	0	0	807
ICH	Ep	D	75	25	0	0	0	0	0	0	0	0	4
ICH	Ep	L	0	0	0	0	0	0	0	0	0	0	18
ICH	Fd	D	55	0	0	0	0	15	0	0	10	0	20
ICH	Fd	L	3	0	0	0	0	0	0	0	0	0	300
ICH	Hw	D	47	2	3	2	2	16	0	3	7	0	102
ICH	Hw	L	26	0	0	1	0	1	0	0	0	0	835
ICH	Pl	D	33	0	0	0	0	0	0	0	0	0	6
ICH	Pl	L	0	0	0	0	0	2	0	0	0	0	63
ICH	Sx	D	57	0	0	0	0	0	0	0	2	2	46
ICH	Sx	L	0	0	0	0	0	0	0	0	0	0	208
SBS	Act	D	100	0	100	0	0	100	0	0	0	0	1
SBS	Act	L	29	0	0	0	0	0	0	43	0	0	7
SBS	At	D	17	4	0	0	0	13	0	4	0	0	24
SBS	At	L	23	0	1	0	0	4	0	4	0	0	102
SBS	Bl	D	0	0	0	0	0	21	0	5	5	0	19
SBS	Bl	L	0	0	0	0	0	0	0	0	1	0	74
SBS	Ep	D	0	100	0	0	0	100	0	0	100	0	1
SBS	Ep	L	22	0	0	0	0	0	0	33	0	0	9
SBS	Fd	D	0	0	0	0	0	0	0	0	0	0	0
SBS	Fd	L	0	0	0	0	0	0	0	0	29	0	7
SBS	Pl	D	4	0	0	0	0	7	0	8	10	0	474
SBS	Pl	L	1	0	0	0	0	0	0	3	1	0	2405
SBS	Sb	D	5	0	0	0	0	3	6	3	13	0	64
SBS	Sb	L	1	0	0	0	0	0	6	1	0	0	333
SBS	Sx	D	5	0	1	0	0	3	3	8	29	0	102
SBS	Sx	L	1	0	0	0	0	0	1	1	1	0	869

APPENDIX 4 Data for Figure 4: Frequency of occurrence (%) for stems in each midpoint diameter class occurring in high, medium, and low wildlife value ranking categories by tree species as per provincial Wildlife Tree policy (see Table 4) for all studies combined.

			% Dead				% Live		
Species	Diam. class	Dead (*n*)	High	Medium	Low	Live (*n*)	High	Medium	Low
Ac	10–15	273	24.18	65.93	9.89	688	2.89	7.47	89.64
Ac	20–35	277	34.36	60.79	4.85	907	1.87	9.70	88.42
Ac	40–50	11	36.36	63.64	0.00	109	0.00	12.84	87.16
Ac	55+	0	0.00	0.00	0.00	10	10.00	0.00	90.00
At	10–15	452	20.80	64.82	14.38	919	1.74	4.57	93.69
At	20–25	122	44.26	43.44	12.30	1388	1.22	6.99	91.79
At	30–40	34	52.94	35.29	11.76	936	0.85	12.50	86.65
At	45+	3	100.00	0.00	0.00	84	3.57	11.90	84.52
Ep	10–15	5	60.00	40.00	0.00	40	2.50	10.00	87.50
Ep	20–25	10	10.00	80.00	10.00	19	0.00	31.58	68.42
Ep	30–40	1	0.00	100.00	0.00	6	16.67	16.67	66.67
Ep	45+	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Bl	10-15	355	1.13	6.76	92.11	1231	8.12	4.14	95.78
Bl	20-35	176	18.75	36.93	44.32	547	1.46	10.79	87.75
Bl	40-50	18	33.33	33.33	33.33	47	6.38	6.38	87.23
Bl	55+	3	33.33	66.67	0.00	2	0.00	0.00	100.00
Cw	10–15	46	2.17	19.57	78.26	200	0.00	1.00	99.00
Cw	20–35	44	15.91	52.27	31.82	308	0.32	3.57	96.10
Cw	40–50	16	31.25	56.25	12.50	114	1.75	7.89	90.35
Cw	55+	16	62.50	25.00	12.50	185	5.95	19.46	74.59
Fd	10–15	10	0.00	40.00	60.00	59	0.00	0.00	100.00
Fd	20–35	4	25.00	50.00	25.00	214	0.00	4.67	95.33
Fd	40–50	3	33.33	33.33	33.33	20	0.00	5.00	95.00
Fd	55+	3	66.67	33.33	0.00	14	0.00	14.29	85.71
Hw	10–15	36	0.00	8.33	91.67	201	0.00	2.99	97.01
Hw	20–35	35	8.57	51.43	40.00	391	0.26	20.46	79.28
Hw	40–50	16	37.50	43.75	18.75	151	0.66	53.64	45.70
Hw	55+	15	66.67	26.67	6.67	92	7.61	51.09	41.30
Pl	10–15	563	1.78	10.48	87.74	1325	0.08	0.68	99.25
Pl	20–35	269	12.64	30.48	56.88	2412	0.70	3.77	95.52
Pl	40–50	10	30.00	40.00	30.00	213	0.47	7.51	92.02
Pl	55+	0	0.00	0.00	0.00	4	0.00	50.00	50.00
Sb	10–15	107	0.93	14.02	85.05	446	0.00	4.48	95.52
Sb	20–35	39	7.69	25.64	66.67	195	0.51	6.15	93.33
Sb	40–50	1	100.00	0.00	0.00	4	0.00	25.00	75.00
Sb	55+	0	0.00	0.00	0.00	0	0.00	0.00	0.00
Sx	10–15	179	3.35	15.64	81.01	957	0.10	0.94	98.96
Sx	20–35	129	13.95	47.29	38.76	1285	0.08	3.27	96.65
Sx	40–50	52	21.15	40.38	38.46	470	0.85	12.98	86.17
Sx	55+	7	14.29	57.14	28.57	83	2.41	15.66	81.93

APPENDIX 5 Data for Figure 5: Relative Frequency of occurrence of trees ranked as per the provincial Wildlife Tree policy (see Table 4) categories for high, medium, and low wildlife value by tree species for all studies combined.

	Tree species									
Rank	**Ac**	**At**	**Ep**	**Bl**	**Cw**	**Fd**	**Hw**	**Pl**	**Sb**	**Sx**
H	9.12	5.41	7.41	1.09	3.98	1.22	2.99	1.38	0.76	1.39
M	23.46	15.85	27.16	5.08	11.09	6.42	26.25	5.48	7.32	7.56
L	67.42	78.75	65.43	93.82	84.93	92.35	70.76	93.14	91.92	91.05

			WT types									
(A)	Study	*n*-Plots	WT1 mn	WT1 sem	WT2	WT2 sem	WT3	WT3 sem	WT4	WT4 sem	WT5	WT5 sem
	Aspen	69	190.14	1.27	5.07	0.36	8.55	0.38	1.16	0.24	0.00	0.00
	Boreal	81	13.27	0.55	0.00	0.00	0.25	0.14	0.00	0.00	0.00	0.00
	ICH	45	101.78	1.05	2.67	0.36	3.56	0.37	2.67	0.32	1.33	0.30
	SBS	50	20.70	0.81	1.00	0.34	1.00	0.29	0.00	0.00	0.00	0.00

	Study	*n*-Plots	WT6 mn	WT6 sem	WT7 mn	WT7 sem	WT8 mn	WT8 sem	WT9 mn	WT9 sem	WT10 mn	WT10 sem
	Aspen	69	51.16	0.67	0.87	0.20	6.52	0.47	18.84	0.53	1.16	0.25
	Boreal	81	17.10	0.57	10.19	0.52	22.65	0.59	16.85	0.54	0.00	0.00
	ICH	45	24.89	0.74	0.22	0.18	2.67	0.35	2.67	0.33	0.67	0.24
	SBS	50	12.00	0.60	15.70	0.80	38.40	0.99	37.90	0.87	0.90	0.00

			Number of types									
(B)	Study	*n*-Plots	1 mn	1 sem	2 mn	2 sem	3 mn	3 sem	4 mn	4 sem	5 mn	5 sem
	Aspen	69	157.39	1.22	48.84	0.65	15.31	0.49	15.71	1.06	1.00	0.00
	Boreal	81	47.86	0.61	20.92	0.59	12.50	1.01	0.00	0.00	0.00	0.00
	ICH	45	99.56	1.07	20.94	0.68	10.91	0.52	1.00	0.00	1.00	0.00
	SBS	50	73.95	0.93	28.18	1.02	24.29	1.04	1.00	0.00	1.00	0.00

APPENDIX 6 Data for Figure 6: Abundance (mean [mn] stems/ha and standard error of the mean [sem]) of specific Wildlife Tree types (WT1–WT10) and number of trees having one or more Wildlife Tree type (1+ to 5+) in Aspen, Boreal, ICH, and SBS Studies.